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**The Ideal Evolution Equation and Fast Magnetic Reconnection**[1]

ALLEN BOOZER, Columbia University — The ideal evolution equation, $\partial\vec{B}/\partial t = \vec{\nabla}\times(\vec{u}_\perp\times\vec{B})$, implies magnetic field lines move with a velocity $\vec{u}_\perp$ and cannot change their connections. Nevertheless, for an electric field that is arbitrarily close to the ideal form, $\vec{E}+\vec{u}_\perp\times\vec{B} = -\vec{\nabla}\Phi$, magnetic connections will in general break on a time scale $\tau\ln R_m$, where $1/\tau \approx |\vec{\nabla}\vec{u}_\perp|$ is the Lyapunov exponent for neighboring streamlines of $\vec{u}_\perp$. The magnetic Reynolds number $R_m \equiv |\vec{u}_\perp\times\vec{B}|/|\mathcal{E}_{\backslash\rangle}|$, where $\mathcal{E}_{\backslash\rangle}$ is the deviation of the parallel electric field from the ideal form. This mathematical theorem is proven in Phys. Plasmas **26**, 042104 (2019) using Lagrangian coordinates, $\partial\vec{x}(\vec{x}_0,t)/\partial t = \vec{u}_\perp(\vec{x},t)$. Though true in two dimensions, the assumption that the part of the magnetic flux that is reconnecting $\psi_p$ must be dissipated by the parallel electric field $\partial\psi_p/\partial t = \int E_{||}d\ell$ is not correct in three. Then, $\psi_p$ can be mixed not destroyed conserving magnetic helicity. Two dimensional theories also effectively exclude exponentiation.

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